

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions and listings of claims in the application:

1. (Currently Amended) A digital watermark embedding apparatus comprising:
an acquisition unit configured to acquire a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be embedded;

a function generation unit configured to generate a topological function corresponding to the topological invariant;

a randomizing-function generation unit configured to generate, based on the key information, a randomizing function by mapping from a first space to a second space, and compute a composite function by composition of the randomizing function and the topological function, the first space and the second space including a target space concerning embedding amounts; and

a function-embedding unit configured to embed the composite function in the target content,

wherein the randomizing-function generation unit generates the randomizing function and computes the composite function to obtain the embedded target content being restored to the target content even if the target content is subjected to geometrical distortion after the composite function is embedded in the target content.

2. (Previously Presented) The digital watermark embedding apparatus according to claim 1, wherein the topological function includes a mapping from a base space concerning positions in the target content to the target space concerning embedding amounts, the mapping being based on the topological invariant.

3. (Original) The digital watermark embedding apparatus according to claim 2, wherein:

the target content includes one of still image data and moving picture data;

the base space is defined by pixel positions corresponding to the target content;

and

the target space is included in a topological space corresponding to a set of assignments of values to pixels composing the target content.

4. (Original) The digital watermark embedding apparatus according to claim 1, wherein the function generation unit generates topological function values which express the topological function.

5. (Original) The digital watermark embedding apparatus according to claim 4, wherein the randomizing-function generation unit generates composite function values by applying the randomizing function to the topological function values, the composite function values expressing the composite function.

6. (Original) The digital watermark embedding apparatus according to claim 5, wherein each of the topological function values and the composite function values indicate embedding amounts corresponding to positions in the target content.

7. (Original) The digital watermark embedding apparatus according to claim 5, wherein the randomizing-function generation unit randomizes the topological function values using a block cipher based on the key information to generate the composite function values.

8. (Original) The digital watermark embedding apparatus according to claim 5, wherein the function-embedding unit embeds the topological invariant by varying the target content based on the composite function values.

9. (Original) The digital watermark embedding apparatus according to claim 1, wherein the function generation unit generates the topological function corresponding to the topological invariant which includes a homotopy invariant.

10. (Currently Amended) A digital watermark detection apparatus comprising:
an acquisition unit configured to acquire key information corresponding to digital watermark information, and a target content in which the digital watermark information is embedded;

a function detection unit configured to detect a function embedded in the target content;

an ordering-function generation unit configured to generate, based on the key information, an ordering function by mapping from a first randomized space to a second randomized space, and compute a composite function by composition of the ordering function and the embedded function, the first randomized space and the second randomized space including a target space concerning embedding amounts; and

a topological invariant computation unit configured to compute a topological invariant based on the composite function, and the topological invariant serving as digital watermark information,

wherein the ordering-function generation unit generates the ordering function and computes the composite function to obtain an embedded target content being restored to an original target content even if the target content is subjected to geometrical distortion after the digital watermark information is embedded in the target content.

11. (Previously Presented) The digital watermark detection apparatus according to claim 10, wherein the composite function includes a mapping from a base space concerning positions in the target content to the target space concerning embedding amounts, the mapping being based on the topological invariant.

12. (Original) The digital watermark detection apparatus according to claim 11, wherein:

the target content includes one of still image data or moving picture data;
the base space is defined by pixel positions corresponding to the target content;
and

the target space is included in a topological space corresponding to a set of assignments of values to pixels composing the target content.

13. (Previously Presented) The digital watermark detection apparatus according to claim 10, wherein the function detection unit detects function values which express the embedded function.

14. (Previously Presented) The digital watermark detection apparatus according to claim 13, wherein the ordering-function generation unit generates composite function values by applying the ordering function to the function values, the composite function values expressing the composite function.

15. (Previously Presented) The digital watermark detection apparatus according to claim 14, wherein each of the function values and the composite function values indicate embedding amounts corresponding to positions in the target content.

16. (Previously Presented) The digital watermark detection apparatus according to claim 14, wherein the order-function generation unit orders the function values using a block cipher based on the key information to generate the composite function values.

17. (Original) The digital watermark detection apparatus according to claim 14, wherein:

the composite function includes a mapping from a base space concerning positions in the target content to a target space concerning embedding amounts, the mapping being based on the topological invariant, the composite function including a parameter which is related to the topological invariant and determines the mapping; and

the topological invariant computation unit computes the topological invariant by acquiring the parameter based on the composite function values.

18. (Original) The digital watermark detection apparatus according to claim 10, wherein the topological invariant computation unit computes the topological invariant which includes a homotopy invariant.

19. (Currently Amended) A digital watermark embedding method comprising:
acquiring a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be embedded;

generating a topological function corresponding to the topological invariant;
generating, based on the key information, a randomizing function by mapping from a first space to a second space, the first space and the second space including a target space concerning embedding amounts;

computing a composite function by composition of the randomizing function and the topological function; and

embedding the composite function in the target content.

wherein generating the randomizing function and computing the composite function obtain the embedded target content being restored to the target content even if the target content is subjected to geometrical distortion after the composite function is embedded in the target content.

20. (Currently Amended) A digital watermark detection method comprising:

acquiring key information corresponding to digital watermark information, and a target content in which the digital watermark information is embedded;

detecting a function embedded in the target content;

generating, based on the key information, an ordering function by mapping from a first randomized space to a second randomized space, the first randomized space and the second randomized space including a target space concerning embedding amounts;

computing a composite function by composition of the ordering function and the embedded function; and

computing a topological invariant based on the composite function, and the topological invariant serving as digital watermark information, wherein generating the ordering function and computing the composite function obtain an embedded target content being restored to an original target content even if the target content is subjected to geometrical distortion after the digital watermark information is embedded in the target content.

21. (Currently Amended) A program stored in a computer readable medium for enabling a computer to function as a digital watermark embedding apparatus, comprising:

means for instructing the computer to acquire a topological invariant as digital watermark information, key information corresponding to the digital watermark information, and a target content in which the digital watermark information is to be embedded;

means for instructing the computer to generate a topological function corresponding to the topological invariant;

means for instructing the computer to generate, based on the key information, a randomizing function by mapping from a first space to a second space, the first space and the second space including a target space concerning embedding amounts;

means for instructing the computer to compute a composite function by composition of the randomizing function and the topological function; and

means for instructing the computer to embed the composite function in the target content,

wherein the randomizing function generating means generates the randomizing function and computes the composite function to obtain the embedded target content being restored to the target content even if the target content is subjected to geometrical distortion after the composite function is embedded in the target content.

22. (Currently Amended) A program stored in a computer readable medium for enabling a computer to function as a digital watermark detection apparatus, comprising:

means for instructing the computer to acquire key information corresponding to digital watermark information, and a target content in which the digital watermark information is embedded;

means for instructing the computer to detect a function embedded in the target content;

means for instructing the computer to generate, based on the key information, an ordering function by mapping from a first randomized space to a second randomized space, the first randomized space and the second randomized space including a target space concerning embedding amounts;

means for instructing the computer to compute a composite function by composition of the ordering function and the embedded function; and

means for instructing the computer to compute a topological invariant based on the composite function, and the topological invariant serving as digital watermark information,

wherein the ordering function generating means generates the ordering function and computes the composite function to obtain an embedded target content being restored to an original target content even if the target content is subjected to geometrical distortion after the digital watermark information is embedded in the target content.